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Engineering development of bank protecting devices using concrete filling textile mats

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Abstract

The article shows the results of the analysis of constructions of bank protection devices, in which concrete filling textile mats are used. Their advantages and disadvantages are shown. It is proved that collaboration of massive concrete elements is provided for well-known technical solutions due to fine concrete straps. Such technical solution is related to the construction disadvantage. The authors indicate that damage of fine concrete straps can lead to the destruction of the whole bank protecting device. The researchers suggest the development of the construction due to strengthening bank protecting device in the zone of fine concrete straps. It is suggested to use pliable metallic strops, located inside textile mats, as inner reinforcing elements for the realization of the project. The paper provides the technical solution, devised by the authors. The developed construction of concrete filling mats will allow upgrading its strength and durability.

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*Keywords:*hydraulic engineering; bank protection; concrete filling textile mats.

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1. Introduction

Bank protecting devices are related to the sphere of hydraulic construction and are used for the protection of wind waves, ice floes and prevention from entrainment of lakes', rivers' and water basins, ground dams' slopes and channels and other hydraulic constructions [1-7].

In the period from 2012 to 2015 more than 500 thousand square meters of the impound ground slopes and banks have been protected by concrete filling mats of various construction types in our country [15, 16]. Mats in the form of "pillows" of Incomat Flex type (Figure 1) are widely spread due to their constructive peculiarities, allowing sustaining wave and ice influences [17-18].

Concrete filling textile mats like Incomat Flex consist of two high-strength woven synthetic cloths, where the space between them is filled with concrete mix at the construction site. The form of a mat represents system of concrete blocks of "pillow" type, that are connected with fine concrete straps.

Filtering elements, that provide removal of filtration pressure, are located in the straps in the angular zones of blocks. Necessary form of concrete filling mats is provided by vertical communications from the woven tapes no more than 5 mm wide, which function as cables, that interconnect canvass and prevent uncontrollable expansion of a mat during the concrete mix supply. The sizes of concrete blocks of the considered types of mats don't exceed 1,5 by 1,5 m, and width of straps is 0,1 m that allows destruction of a monolithic covering within the fine straps in case of considerable external influence or a foundation settlement to provide destruction of a monolithic covering within the fine straps, preserving integrity and reliability of the whole bank protecting design.

Fig. 1.General view of concrete filling textile mats.

Theanalysisofconstructivepeculiaritiesofconsideredtypesofconcrete filling textile mats, work conditions as well as carried out field and theoretical research [19-20] revealed their considerable disadvantage. Thus, the collaboration of massive concrete blocks of mats is provided, mainly, due to concrete straps, after the destruction of which, the sustainability of the construction is provided by woven fabric. The preservation of woven fabric during the whole time period of bank protecting constructions, according to authors, is not likely to happen, and can lead to the deformation of the rakers, soil grain entrainment of the slope and destruction of bank protecting construction.

In order to improve the safety of the existing concrete filling mats it is necessary to apply additional constructive solutions that allow normal functioning of concrete elements of textile mats and after concrete destruction in the straps.

2. Research

The identified shortcomings of the existing types of bank protecting devices using concrete filling textile mats show two ways of their construction improvement: introduction of additional elements in order to provide collaboration of concrete blocks and after the destruction of concrete in the straps; introduction of additional

elements aiming at providing safe work of separate concrete blocks, including those after the destruction of concrete in the straps.

Implementing the first way of improvement, authors have developed a design of a concrete filling mat [21] with the following additional elements (figure 2): flexible rakers, internal reinforcing elements, damping layers, filtering cloth.

Each flexible raker is connected by one end to the top canvas in a junction of flexible brace poles, and other end – to the lower canvas in a junction of the adjacent flexible brace pole. The internal reinforcing elements in the form of flexible cables, are placed inside each concrete block between flexible vertical brace poles and spread all over the mat. The damping layers made of elastic porous material in the form of flexible canvas are located under concrete blocks, without overshoot of the filtering elements and crossing points, and attached to the filtering canvas located on a surface of the protected slope. A pitch of the internal reinforcing elements, brace poles and rakers are selected from uniform spacing in blocks, taking into account tensions in the construction.

Strength and deformative characteristics of covering elements, length and pitch of brace poles and rakers are selected from conditions of ensuring reliability of their work while laying, filling with concrete, external influences during operation and ensuring stability within the protected construction.

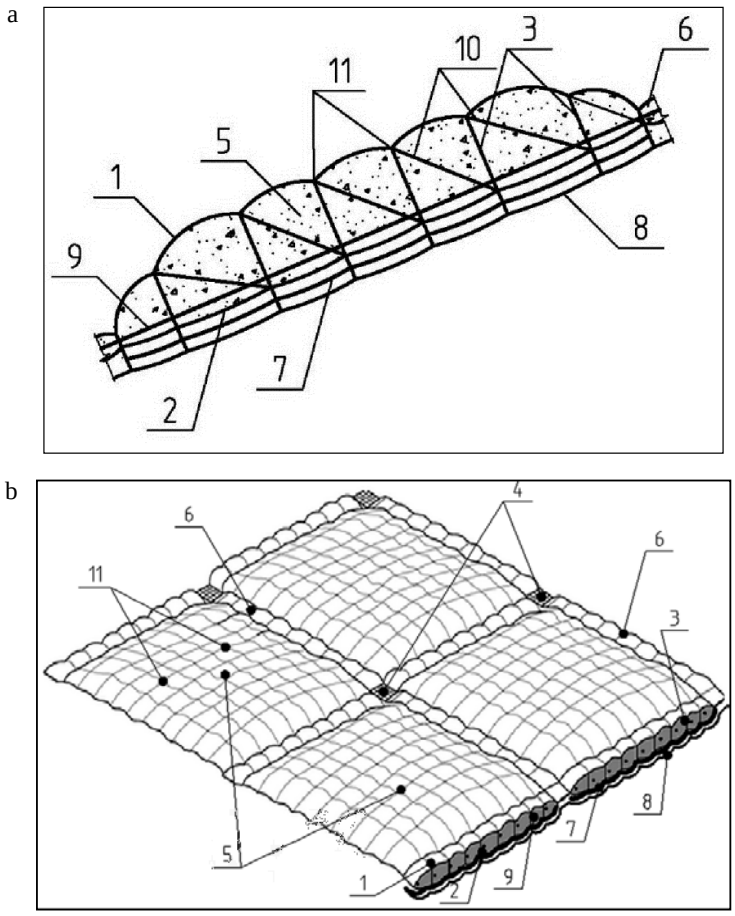

Fig. 2. Scheme of construction improvement of concrete filling textile mats: (a) cross section, profile drawing; (b) plan.

In Fig. 2: 1 – upper canvas; 2 – lower canvass; 3 – flexible rakers ; 4 – filtering element; 5 – concrete block; 6 – strap; 7 – damping layer; 8 – filtering canvass; 9 – internal reinforcing element; 10 – flexible rakers; 11 – location of through-wall broaching canvass.

The internal reinforcing elements provide increasing durability of concrete blocks, their interconnection and after destruction of concrete in crossing points, the damping layers will amortize part of external dynamic influences, the filtering canvass prevents entrainment of soil grains from a slope, flexible rakers provide reliable connection of the upper canvass and lower canvass that will totally increase the general reliability of a bank protecting construction.

Among other ways of improvement the concrete filling mats, authors have offered a construction (figure 3) with the following additional elements: reinforcing canvass, anchor device, filtering canvass. The reinforcing canvass are nailed to the filtering canvass under each concrete block to one end in one or several horizons of internal brace poles location, and are attached to another end to the anchor devices located inside the slope.

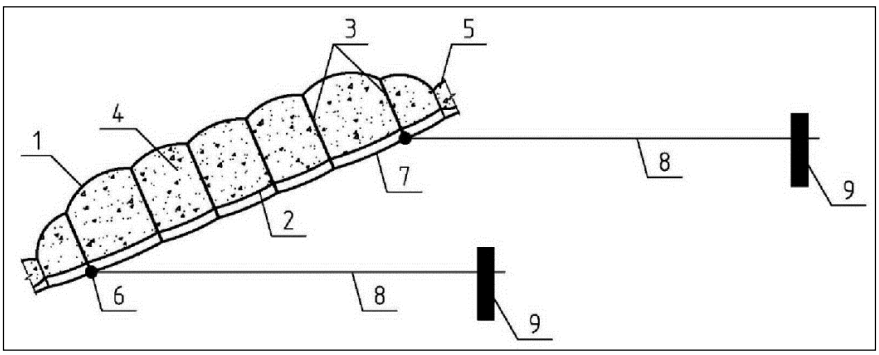

Fig. 3. Improved construction of concrete filling textile mats: cross section, profile drawing.

In Fig. 3: 1 – upper canvass; 2- lower canvass; 3 – flexible rakers; 4 – concrete block; 5 – strap; 6 – location of through-wall broaching reinforcing canvass, filtering canvass and brace poles; 7 – filtering canvass; 8 – reinforcing canvass; 9 – anchor device.

Reinforcing canvasses are made of flexible woven synthetic water-proof geofabric or geoweb material, filtering canvass made of water-proof nonwoven fabric. Anchor devices are represented as metal rods covered with a corrosion-resistant coating. Installation of the reinforcing canvasses and anchor devices is provided in the process of dumping of the protected slope. The quantity of the reinforcing canvasses spread over one concrete block, their length, strength and deformative characteristics, and also pitch and sizes of anchor devices are chosen taking into account tension arising in construction from conditions of ensuring stability of concrete blocks within the protected slope. Existence of the reinforcing canvasses and anchor devices provides stability of concrete blocks, even after destruction of straps, the filtering canvass prevents entrainment of soil grains from the protected slope and consequently reliable work of a bank protecting construction.

Thus, the improved bank protecting devices, developed by authors with application of concrete filling textile mats, due to use of additional constructive solution, will allow to increase considerably their durability, stability, durability, and therefore, their reliability.

3. Conclusion

The executed research of construction of bank protection devices, using concrete filling textile mats, provides the following possible outcomes.

The analysis of bank protecting devices using concrete filling textile mats has proved the presence of essential disadvantages. Collaboration of massive concrete elements of textile mats is provided for the known technical solutions, generally only at the expense of thin concrete straps, destruction of which can lead to an emergency situation in a construction.

- Proceeding from the revealed disadvantages of the concrete filling textile mats, authors have chosen two ways of construction improvement: introduction of additional elements for the purpose of improvement of collaboration of concrete blocks or ensuring reliable operation of separate concrete blocks after destruction of concrete in straps.
- Two designs of mats, having the following additional elements, that have been developed for realization of the offered ways of improvement the concrete filling textile mats: 1 – rakers, the internal reinforcing elements, damping layers, filtering canvass; 2 – the reinforcing canvass, anchor devices, filtering canvass.

Advanced constructions of bank protection devices, developed by authors, using concrete fillingtextile mats, that will allow to increase their durability, reliability and durability.

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